County Roscommon Groundwater Protection Scheme

A Description of Groundwater Quality



Tobermore Springs, Killeglan Water Supply Scheme, County Roscommon

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1 Introduction

This report aims to provide an overview of the groundwater quality characteristics of selected supply sources in County Roscommon. Relationships are examined between water quality problems and human pressures, vulnerability and well construction. An understanding of these relationships will help decision-makers prioritise:

- hazard surveys,
- remedial measures,
- well construction measures, and
- more detailed water quality monitoring.

The report is intended for use by engineers, planners, regulators and hydrogeologists who are considering the distribution and cause of water quality problems across the county. Unless augmented by field-based hazard assessments at the supply source(s) in question, this report is not suitable for use in identifying specific issues at individual water supply sources.

2 Scope

2.1 Key Concepts

The report aims to describe the groundwater quality situation in Roscommon and to assess the likely causes of groundwater quality problems.

Assessments are based primarily upon laboratory analyses of raw water samples taken prior to treatment from most of the major groundwater abstractions in County Roscommon i.e. the Public Supplies and Group Schemes. Attention is focused upon the following selected indicators of contamination: nitrates; chloride; phosphates; ammonia; faecal coliforms; potassium; sodium; iron and manganese. Concentrations of these indicators in each supply are compared with GSI recommended guide levels to help to identify the degree of contamination and likely pollution sources.

As described in Appendix I, the contaminant indicators are also helpful in diagnosing the following contamination hazards: landspreading, on-site waste-disposal systems (e.g. septic tank systems), and farmyard point hazards. There are many other potential hazards, such as manufacturing industry and small commercial enterprises. Though individual pollution incidents related to these activities can be serious in terms of public health, they are likely to be localised, and rarely influence the regional groundwater quality situation. Consequently, such activities are not considered in this report.

2.2 Limitations

The distribution and causes of raw groundwater quality problems are discussed in the context of the contaminant indicators and contaminant hazards described above. Public health considerations are a matter for the relevant Health Authorities. Issues relating to other parameters, such as pesticides and hydrocarbons, and other activities, such as petroleum storage and sheep dipping, are not considered in this report.

No detailed, specific field hazard surveys have been undertaken by GSI. The assessments have been made on the basis of water quality data and cannot be used to link quality problems with specific enterprises unless they are accompanied by field hazard surveys. It is envisaged that any field hazard surveys that are required will be undertaken or commissioned by the Council and/or the relevant Health Authority.

3 Methodology

3.1 Selection of Groundwater Supplies

Appendix II outlines the list of supplies under consideration. Only groundwater supplies which are consistently used and with higher yields were selected. This was to ensure that the abstractions sampled were as representative of the groundwater quality in an area as practicable. Thus supplies

with less than 50 m³/d were *generally* not considered. In the case of Group Schemes, where discharge data is generally not available, the discharge from the source was estimated by multiplying the number of houses and farms on the scheme (where supplied by the Council) by 0.65 m³/d for each house and 15 m³/d for each farm.

A total of fifty-one supply sources were used in the study. These comprise ten Public Supply Sources (nine of which are springs) and forty-one Group Supply Sources (nineteen of which are springs). Locations of these supplies are provided on Maps 4N, 4S and 4W.

3.2 Data Sources

In order to compile this report data from the period 1997 to 2002 were used. The sources of data are shown in Table 1 below.

Information Source	Analytical Laboratory	Analytical I	Parameters	No. of Sources	Type of Source ¹
		Inorganic	Bacterial		
<i>GSI</i> Specific sampling undertaken in February and again in September 2001. Mainly raw, some treated water samples.	Inorganic Parameters: State Laboratory, Abbotstown, Co. Dublin Bacterial Parameters: Roscommon County Council, Courthouse, Roscommon Town.	4	~	41	PWS, GWS
<i>EPA</i> On-going sampling – data were taken for the period 1997 to 2002. Raw water samples.	EPA Regional Inspectorate, Castlebar, County Mayo	4		10	PWS
County Council $(1999 - 2001)^2$ Mainly raw, some treatedwater samples.	Roscommon County Council, Courthouse, Roscommon Town.	V	~	40	PWS, GWS

Table 1. Source of Data and Data Analyses.

1. PWS – Public Water Supply Schemes; GWS – Group Water Supply Schemes.

2. These data were mainly assessed in the Rural Water Monitoring Project (Roscommon County Council, 2000). Only some of these data were analysed in this report to provide further information for specific parameters.

Data from the County Council were also used for specific parameters however, an assessment of these data have been undertaken in the Rural Water Quality Monitoring Report assessed monthly results over the period of a year (March 1999 to March 2000) for 56 private Group Water Schemes and eight semi-private Group Water Schemes. Although the private Group Water Schemes category includes nine surface water schemes, the remainder are groundwater abstractions which generally correspond to the supply sources used in the present report. Although the finding from Rural Water Quality Monitoring Report are not specifically discussed here, the more salient points for some of the key contaminants are given in Section 5.

A detailed examination of other, less readily-available data sources such as individual academic theses or consultants' reports, was beyond the scope of the report.

3.3 Data Accuracy and Screening

- For samples taken after treatment, data on total and faecal coliforms were ignored unless counts were above 0/100 ml.
- Data was disregarded where there was a possibility that the waters sampled were a mix of ground and surface water.

- Data which were anomalous to the general trend in a given supply source was, where possible, verified with the lab that carried out the analysis. Where verifications were not possible, strongly anomalous data was omitted.
- Ionic balances were carried out on those samples where all major ions were analysed.

3.4 Data Analysis

Generally, it is useful to assess the distribution of each of the key contaminant indicators in terms of groundwater vulnerability, aquifer classification and well type.

Aquifer Classification. Contaminant migration potential is similar in most Irish bedrock aquifers as these are dominated by flow through fissures, fractures, bedding and joints. However a large proportion of County Roscommon is underlain by karstified limestone (Lee and Daly, 2002) and 45 of the 51 supply sources are located in karstified aquifers. Consequently it is unlikely that any major differences in water quality can be attributed to different aquifer types.

Groundwater Vulnerability. In most hydrogeological settings there is a good link between the vulnerability as shown on a vulnerability map and the water quality. Areas of 'low' vulnerability normally correspond to good quality groundwater, both microbially and chemically, whereas contamination is frequently evident in areas of 'extreme' vulnerability. However, the link is less clearcut in karst areas. Groundwater recharge and flows in these areas are complex and difficult to predict. While a substantial proportion of recharge usually occurs diffusely over the land surface, enabling a good link between vulnerability and groundwater quality, some of the recharge occurs at swallow holes and other karst features, where the overlying soil and subsoil layers are bypassed. Furthermore the flow rates through karst rocks can be significantly faster than in other rocks e.g. minimum flow velocities of 25 m/hr have been recorded in the Roscommon Town area and 280 m/hr in the Boyle area. Consequently any contaminants in the recharging surface water can directly enter the groundwater system and rapidly reach the abstraction point (spring or borehole) with minimal attenuation, even from a number of kilometres away. Therefore, groundwater quality in a karst spring reflects not only the regional vulnerability, but also the 'extreme' nature of the vulnerability in the vicinity of karst features, such as sinking streams.

Consequently any contaminants in the recharging surface water can directly enter the groundwater system and rapidly reach the abstraction point (spring or borehole) with minimal attenuation, even from a number of kilometres away. Over such large distances it is possible that the vulnerability category may, and frequently does, change. Thus in karst regions it is probably more relevant to know the vulnerability categories throughout the catchment area contribution groundwater to the spring or borehole rather than the category at that particular point. Catchment areas for most of the sources have not been delineated and therefore this particular aspect of the groundwater quality has not been fully explored in this report.

Well Type. The direct ingress of surface water or very shallow groundwater is a common cause of drinking water contamination. Specific information on well construction and well-head protection measures is not readily available for the majority of the supplies in Roscommon. However, it is likely the boreholes are less susceptible to surface water inundation than springs as they are generally deeper. Furthermore, springs in karstified areas are often directly linked to point recharge features (e.g. swallow holes, dolines).

Given the types of sources in Roscommon and the available data, the fifty-one supplies have been divided into 2 well type categories: *boreholes* and *springs*. The distribution of each key contaminant in Section 5 is described in terms of these well type categories.

Having examined the distribution in general terms, the supplies were grouped to provide a prioritisation for additional action measures. Groupings were made on the basis of concentrations of key contaminant indicators in relation to the European Union Maximum Admissible Concentration (MAC) and to the GSI guide levels as follows:

• *Group 1:* Sources in which one or more contaminant indicators in the available data set exceeded 10 counts/100 ml for faecal coliforms, or the EU MAC for the remaining indicators.

- *Group 2:* Sources which show concentrations of the contaminant indicators chloride, nitrate, ortho-phosphate, iron, manganese and potassium:sodium ratio GENERALLY in excess of the GSI guide levels (or faecal coliforms >0 in any one sample). Some interpretation is required as levels in excess of these guide levels can reflect natural conditions in some cases (e.g. elevated potassium and/or iron can occur naturally in sandstone groundwaters).
- *Group 3:* Sources with slight anomalies in the analyses which may be naturally induced or indicative of some slight contamination (i.e. indicator levels OCCASIONALLY in excess of the GSI guide levels or possible EU MAC).
- *Group 4:* Sources showing no evidence of contamination from the analyses carried out for the project.

Results of the grouping exercise are outlined in Section 6. Section 7 uses the combination of contaminant indicators at each supply to provide some guidance on the generic type of hazards that might be influencing groundwater quality.

4 Groundwater Occurrence and Exploitation in Roscommon

4.1 Geology, Aquifers and Vulnerability

The vulnerability of the groundwater and the flow regimes within an aquifer both have a strong bearing on the ease with which contaminants can reach a supply source abstracting from it. Lee and Daly (2002) discuss the geology and consequent aquifer characteristics in the county, and outline the basis for vulnerability classifications.

Certain water quality issues can be derived from natural conditions within the aquifers and subsoil. Depending on local hydrochemical processes such as oxidation and reduction, problems can include:

- Iron/manganese in sandstone and shaly limestone aquifers.
- Hydrogen sulphide in shaly limestone aquifers.
- Hardness in limestone aquifers.
- Corrosion in sandstone, mudstone, granite and volcanic aquifers where they are overlain by thin subsoil.

Where applicable, these issues are discussed further as part of aquifer classification in the Roscommon Groundwater Protection Scheme Main Report (Lee and Daly, 2002).

4.2 Exploitation

A large proportion of the drinking water in County Roscommon is supplied by groundwater: 12 of the 15 Public Water Schemes (approximately 73% of water abstracted), and 47 of the 56 Group Water Schemes (based on County Council figures, 1999). Areas not served by Public or Group Water Schemes generally rely on individual private wells as their source of water.

5 Indicators of Groundwater Contamination

5.1 Introduction

GSI has developed guide levels for certain key chemical and microbiological parameters. These guide levels can be used to help indicate situations where the water quality of a groundwater supply source has been affected to a significant degree by certain human activities but not necessarily to the extent that concentrations exceed the EU MAC for drinking water. In essence, the indicators help identify groundwater supply sources which are *contaminated* but not necessarily *polluted*. The benefits of examining contamination in addition to pollution are:

- An 'early warning' can be provided for supplies which may become polluted in the future.
- Evidence of contamination may provide an indication that the supply is polluted at certain times of the year but that these incidences of pollution are not being identified by the existing monitoring regime.

Consequently, supplies with concentrations of indicator parameters above GSI guide levels may benefit from measures including additional monitoring, improved well-head engineering and hazard surveys to help prevent more significant water quality problems.

In addition, an examination of the combination of indicator parameters exceeding GSI guide levels can provide valuable information on the cause of the water quality problems at a supply source. For example, depending on the nature of the geology, a ratio of potassium to sodium ('K:Na ratio') greater than 0.4 can be used to indicate contamination by plant organic matter - usually from farmyard 'dirty water', but occasionally from landfill sites (from the breakdown of paper). The use of contaminant indicators is described in more detail in Appendix I.

The key indicators are given below, along with the GSI's guide levels and the EU MAC level:

Parameter	GSI Guide Level (mg/l)	EU MAC (mg/l)		
Faecal bacteria	0	0		
Nitrate	25	50		
Potassium	4	12		
Chloride	30	250		
Ammonia	0.15	0.3		
K/Na ratio	0.4	-		
Phosphate (as P)*	0.03	2.2		
Iron**	-	0.2		
Manganese**	-	0.05		

*Levels higher than the guide are likely to influence river phosphate problems where the groundwater contribution to the annual river flows is significant. This will depend on the volume of water and concentration of phosphate both in the river as well as the contribution groundwater.

**Elevated levels of iron and manganese, though often influenced by the natural geology, can also provide an indirect indication of contamination.

Sections 5.2 to 5.8 provide a discussion of each contaminant indicator in the context of:

- *Occurrence:* the number of supplies where one or more available analysis exceeds the GSI guide level or EU MAC.
- *Variation with time:* any water quality trends that are apparent in those supplies where sufficient data are available.
- *Distribution:* the links between contaminant levels, the vulnerability of the groundwaters feeding the supply and the inferred quality of the supply construction. The methodology is explained in Section 3.4.

5.2 Faecal Coliforms

Background: Faecal coliforms are commonly analysed because they are easily detected and identified and because they originates in the intestine, along with many pathogenic organisms. More information is provided in Appendix I. At the time of writing, the Rural Water Quality Monitoring Report (Roscommon County Council, 2000) stated that 58% of 1094 private Group Water Scheme *samples*¹ have faecal coliforms present. The report does not state whether any *supply sources* were free of faecal coliforms however, it does note that only one groundwater Group Supply Scheme (Tartan/Scurmore) was free of <u>total</u> coliforms. Since the publication of this report, total coliforms have been identified in all of the supply sources.

Occurrence: Summary water quality information for each supply source is presented in Table 2 and in graphical form in Appendix III. Analytical results are presented in Appendix IV.

¹ The Rural Water Quality Monitoring Report gives these results in terms of total sample number rather than per individual source. These samples also include those taken from 9 surface water sources but which has not been distinguished.

G		Т	Exceedances by Key Indicators of Contamination ²								
roup	Supply Source	уре	NO ₃	Cl	PO ₄	NH _x	faecal coliforms	К	K:Na	Fe	Mn
	Ardkeenagh/Cloonanart Beg	Sp^{3}				ĺ	Excess 10				
	Aughrim	Śp			Guide		Excess 10				
	Ballinagard	Sp			Guide		Excess 10	Guide	Guide		
	Ballinderry	Sp					Excess 10				
	Ballinlough	Sp			Guide		Excess 10	Guide	Guide	MAC	MAC
	Ballymacurley, Kiltultoge	Sp			Guide		Excess 10				
	Carroward	Bh			Na ⁴		Excess 10				
	Carrownalassan/Coggal	Sp					Excess 10				
	Castlerea: Longford	Sp			Guide		Excess 10				
	Castlerea: Silver Island	Sp			Guide		Excess 10		Guide	MAC	
	Cloonagrassan	Bh			Guide		Excess 10				
	Cloonmore, Termonbarry	Bh		Guide		Guide	Excess 10	Guide		MAC	MAC
	Cloonyquin	Sp			Guide		Excess 10				
	Derrane/Coolteige	Sp					Excess 10				
I	Dunamon	Sp					Excess 10				
	Emlaghmore	Bh			na		Excess 10				
	Keadew	Bh			Guide		Excess 10				
	Kilbarry	Bh			Guide		Excess 10		~		
	Killeglan	Sp			Guide	MAC	Excess 10	MAC	Guide		
	Knockcroghery (Tobereeoge)	Sp			Guide		Excess 10				
		Sp			Guide		Excess 10				
	Mount Talbot (Cloonlaughnan)	Sp			Guide	0.11	Excess 10			MAC	
	Ogulla	Sp	MAG	0.11	0.11	Guide	Excess 10	MAG	0.11		
	Didtown, Clonown	Sp Sn	MAC	Guide	Guide	Cuida	Excess 10	MAC	Guide		
	Peake, Mantuar	Sp Sn			Guide	Guide	Excess 10				
	Raincarran	Sp			Guide	Cuida	Excess 10				
	Ratinmore	Sp Sp			Cuida	Guide	Excess 10	Cuida	Cuida		MAC
	Toborovoddy	- Sp - Dh			Guide		Excess 10	Guide	Guide		MAC
	Broome	DII			Ila		Excess IU				
	BIOSIIA Carana Pallintahar/Correctaona	Sp Sp			Guida		Excess 0				
	Caralie, Dallillobel/Collastoolia	- Sp Dh			Guide		Excess 0				
		Dil Sn					Excess 0				
	Carroweighter	Sp Sp		Guida			Excess 0				
2	Carrowkeel	Bh		Guide			Excess 0				
4	Clooptuskert Village	Bh					Excess 0				
	Corraun Whitehall	Bh					Excess 0	Guide	Guide		
	Derringcartha/Cloonlumney	Sn			Guide		Excess 0	Oulue	Oulde		
	Oldtown Ballinameen	Bh			Guide	Guide	Excess 0				MAC
	Rahara Road	Sn				Guide	Excess 0				MAC
	Ballinameen	Bh				Guide	* 5			MAC	MAC
	Caran/Castlenlunket	Bh				Guide				MAC	MAC
	Cloopmore Whitehall	Bh				MAC	*			MAC	MAC
	Compton/Quinn	Bh			na	MAC	na			MAC	MAC
3	Flagford	Bh			na	MAC	*			MAC	
	I vonstown	Rh			na	MAC				1	1
	Spollen/Rogers	Bh		L	114		*	l		MAC	MAC
	Tartan/Sourmore	Bh		L	l	MAC	*	l		- mat	MAC
	Carnicka	Bh					*				mae
X ⁶	Castlastrança	Rh		l	no	l	no		l	l	
1	Mullymueks	- DII Rh			na		na				
	IVIUIIVIIIUCKS	DII			i na		11111				

Table 2. Water Quality Classification of Selected Roscommon Groundwater Sources

 $^{^{2}}$ NO₃: Nitrate, Cl: Chloride, PO₄: Phosphate, NH_x: Ammonia, K: Potassium, K:Na ratio: potassium:sodium ratio. Fe: Total Iron. Mn : Manganese, NH_x: Ammonia.

³ Sp: Spring Supply. Bh: Borehole Supply.

⁴ Not Available.

⁵ * zero faecal coliforms but incidences of greater than zero total coliforms counts/ml, and in some cases greater than 10 counts/ml.

⁶ No exceedances of GSI guidelines or EU MAC however, there is limited data available for some of the key contamination indicator and hence a representative classification was not be determined.

The results highlight that:

- Faecal coliforms are the most commonly found pollutant in the selected Roscommon supply sources. Faecal coliforms are in excess of 0 counts/100 ml in one or more raw water samples from 40 (78%) of the 51 supply sources.
- One or more raw water samples have greater than 10 counts/100 ml in 29 supplies (57% of all supplies studied), including all ten of the currently used Public Supply abstractions.

It is stressed that these figures do not necessarily represent human health concerns. Samples are mainly of 'raw waters', having been taken from points prior to water treatment at the supplies.

Variations with time: No strong trends were detected.

Distribution: Results are shown in Figure 1 and the methodology is explained in Section 3.4.



Figure 1. Faecal Coliforms in Relation to Well Type.

The key points to note are as follows:

- All of the 28 springs sources have faecal coliforms present. Twenty springs have greater than 10 faecal coliform counts/100 ml. The borehole sources are more likely to have no, or lower levels of, faecal coliforms; 11 of the 23 boreholes do not have faecal coliforms present and a further five boreholes have less than 10 count/100ml. Boreholes generally have specific well-head protection designed to prevent the ingress of surface waters or very shallow groundwaters. Karst springs are more frequently associated with point recharge and shallower groundwater flows and thus are more likely to be susceptible to contamination.
- Six of the springs with faecal coliforms present also have elevated potassium:sodium ratios i.e. greater than 0.4, which suggest that the organic waste is from a nearly farmyard rather than septic tank source.
- Six of the sources with elevated faecal coliforms also have elevated levels of ammonia (> 0.15 mg/l), which would confirm contamination by organic wastes. Ammonia is known to have low mobility and hence its presence would suggest there the hazard is either nearby or that the groundwater is extremely vulnerable in some part of their catchments (refer to Section 3.4).

5.3 Nitrate

Background: As the normal concentration in uncontaminated groundwater is low (less than 5 mg/l), nitrate can be a good indicator of contamination by fertilisers and waste organic matter. The nitrate ion is not adsorbed on to clay or organic matter. It is highly mobile, and under wet conditions is easily leached out of the rooting zone and through soil and permeable subsoil. Consequently, groundwater nitrate concentrations are more influenced by dilution and less influenced by groundwater

vulnerability than concentrations of parameters such as faecal coliforms or ammonia. More information is provided in Appendix I. Results in Rural Water Quality Monitoring Report (Roscommon County Council, 2000) highlight that there are generally low levels of nitrates in all of the sources in Roscommon, including the surface water sources. Only 23 of 1099 *samples* taken from the sources exceeded 20 mg/l NO₃ and none of the samples exceeded the EU MAC (50 mg/l).

Occurrence: Summary water quality information for each supply source is presented in Table 2 and in graphical form in Appendix III. Analytical results are presented in Appendix IV. The results highlight that:

- Of the sources analysed, there is negligible nitrate contamination in Roscommon. Only one of the 51 sources (2%) has a nitrate level in excess of the EU MAC (50 mg/l). The same source (Oldtown Clonown) had two (of five) exceedances of the GSI guide level of 25 mg/l. An explanation of the GSI guide level and the EU MAC is provided in Section 5.1.
- Sixteen of the sources (31%) have exceeded 10 mg/l on more than one occasion, 6 of which are Public Supplies. This level would suggest that there is *some* nitrate contamination from human activities however such a level is not significant from a public health perspective.

Variations with time: Of the fifty-one supply sources examined, 12 have more than four data points since 1999. No obvious long term trends are detectable although the Rockingham, Knockcroghery and Lecarrow springs all show a slight seasonal variation. These data sets are not comprehensive enough to be conclusive.

Distribution: Results are presented in Figure 2 and the methodology is explained in Section 3.4.



Figure 2. Nitrate in Relation to Well Type.

Key points to note are as follows:

- One spring source (Oldtown Clonown) exhibited elevated nitrate levels; it exceeds the EU MAC on one occasion and the GSI threshold on two occasions. This particular spring also has elevated potassium:sodium ratio and chloride levels. These indicators would suggest nearby farmyard sources of organic waste. This spring is located in a locally important aquifer (Ll), which is extremely vulnerable. Given that this is a spring source and a number of indicators are elevated, it is probable that contamination is occurring at, or very near to, the source.
- There are lower nitrate levels in the boreholes than in the springs. 65% of the borehole have 5 mg/l or less, as opposed to only 25% of springs. Furthermore 78% of the boreholes have less than 10 mg/l compared to 57% of the springs. These results would verify that the boreholes are generally less susceptible to contamination.
- Although twenty two sources have values of 5 m/l or less, which is comparable to uncontaminated levels, 14 of these have faecal coliforms present, a further five (borehole supplies) have elevated ammonia and another borehole supply has elevated iron and

manganese. Elevated levels of these parameters would indicate that there is contamination from human activities at these sources.

• As nitrate is a mobile cation, the relatively low levels of nitrate suggest that there is a combination of a) less intensive farming in Roscommon than, for instance, in the south-east of the country and b) dilution occurring by higher recharge.

5.4 Ammonia

Background: Ammonia concentrations in excess of 0.15 mg/l (as NH₃ or NH₄) are generally indicative of contamination from organic wastes and suggest that pathogenic micro-organisms may also be present (Flanagan, 1992). Ammonia has a low mobility in soil and subsoil and its presence at concentrations greater than 0.15 mg/l in all but the most vulnerable groundwater indicates a nearby point organic waste hazard and/or poor well construction. More information is provided in Appendix I. Monitoring undertaken for the Rural Water Quality Monitoring Report (Roscommon County Council, 2000) highlights that 60 *samples* from nine different Group Schemes⁷ exceed the EU MAC of 0.3 mg/l.

Occurrence: Summary water quality information for each supply source is presented in Table 2 and in graphical form in Appendix III. Analytical results are presented in Appendix IV. Key points to note are as follows:

- Twelve of the 51 sources (24%) have one or two exceedances of the GSI guide level. Ten of these exceeded the MAC (0.3 mg/l); six borehole sources and four spring sources. An explanation of the GSI guide level and the EU MAC is provided in Section 5.1.
- Only one of the ten Public Supplies (Killeglan) exceeded the MAC ammonia guide level on one occasion.

Variations with time: In the sources with more than four data points, levels are generally low and temporal or seasonal variations cannot be detected.





Figure 3. Ammonia in Relation to Well Type.

The main points to note are:

- Ammonia levels are generally low in the sources analysed.
- One of the eight samples taken from the Killeglan Public Water Supply (spring) has an ammonia level in excess of the EU MAC. This corresponded with elevated faecal coliforms

⁷ The Group Schemes with elevated ammonia levels are not specified in the Rural Water Quality Monitoring Report and therefore possibly including surface water schemes.

and an elevated potassium:sodium ratio. Similarly, the sample with elevated ammonia in the Cloonmore Termonbarry Group Scheme also had faecal coliforms and an elevated potassium level. All of these parameters indicate that manure or slurry in a nearby farmyard is the likely source of pollution.

- Seven of the Group Water Schemes (Ballinameen, Cloonmore Whitehall, Compton Quinn, Flagford, Lyonstown, Oldtown Ballinameen and Tartan/Scurmore) exhibit elevated ammonia and all but Flagford and Lyonstown also have elevated iron and/or manganese. Although these parameters can indicate reducing conditions in groundwater which is contaminated by organic effluent, there is an absence of nitrate, chloride or faecal coliform problems in the available data set. It is therefore likely that these levels are associated with more natural causes; runoff from peat areas close to these sources or the impure nature of the bedrock.
- The remaining three sources with elevated ammonia also have faecal coliforms present but do not have high potassium:sodium ratios. These sources are located in regionally important karstified aquifers. Ammonia is not particularly mobile but the karstic nature of the aquifers can allow for rapid transmission of ammonia over large distances with little or no attenuation.

5.5 Chloride

Background: Chloride, like nitrate, is a mobile cation. It is a constituent of organic wastes and levels appreciably above background levels (say in excess of 30 mg/l) have been taken to indicate contamination by organic wastes. More information is provided in Appendix I.

Occurrence: Summary water quality information for each supply source is presented in Table 2 and in graphical form in Appendix III. Analytical results are presented in Appendix IV. Key points to note are as follows:

• Only three Group Schemes of the 51 supply sources (6%) have several sample results in excess of the GSI guide level of 30 mg/l. Two of these are spring sources (Oldtown Clonown and Carroweighter) and the third (Cloonmore Termonbarry) is a borehole source. An explanation of the GSI guide level and the EU MAC is provided in Section 5.1.

Variations with time: None of these datasets demonstrate a discernible pattern.

Distribution: Chloride itself is not generally considered to be a contaminant of concern but is mainly studied in combination with other contaminants to help identify possible hazards. The main point to note:

• Chloride is one of a number of elevated parameters in the Oldtown Clonown spring and Cloonmore Termonbarry borehole. These also include faecal coliforms, ammonia, iron and manganese at Cloonmore and faecal coliforms and high potassium:sodium ratio at Oldtown. These elevated parameters indicate nearby sources organic wastes (e.g. farmyard and septic tank sources).

5.6 Potassium and Sodium

Background: The potassium:sodium ratio of soiled water and other wastes derived from plant organic matter is considerably greater than 0.4, whereas the ratio in septic tank effluent is less than 0.2. Consequently a potassium:sodium ratio greater than 0.4 can be used, subject to some geological constraints, to indicate contamination by plant organic matter - usually from poorly managed farmyard 'dirty water', and occasionally landfill sites (from the breakdown of paper). More information is provided in Appendix I.

Occurrence: Summary water quality information for each supply source is presented in Table 2, and in graphical form in Appendix III. Analytical results are presented in Appendix IV. Key points to note are as follows:

• Of the 51 supplies examined, available potassium:sodium ratios from seven (12%) are in excess of the 0.4 guide level. An explanation of the GSI guide is provided in Section 5.1. None of the seven sources occurs in sandstones, granites or mudstones, where the ratio might have been affected by naturally elevated potassium. Further, ratio peaks in all seven supplies are generally coincident with peaks in either faecal coliforms, ammonia or nitrate.

Consequently, it is thought *unlikely* that the elevated ratios are due to natural geological causes in any of the six sources.

• Of the seven supply sources, six are springs and five of these springs are Public Water Supply Schemes.

Variations with time: No long term trends are apparent in the available data set.

Distribution: There are two main points to note from the assessment of potassium:sodium ratios:

- There were elevated levels in the Ballinagard and Ballinlough Public Water Supplies on more than two occasions. In most instances this is due to potassium levels which are at, or near, the GSI guide (4 mg/l). Given the combination of contamination indicators at these springs and their high discharge, it is likely that the influence of potassium from one or two farmyard point hazards would be diluted to low levels. Diffuse landspreading of organic and inorganic fertiliser are therefore also thought to be a possible influence on potassium concentrations. Potassium is relatively immobile in soil and subsoil and potassium spread on the soil surface will generally attenuate before reaching groundwater. However, in areas of extreme vulnerability, intensive applications of potassium may result in elevated potassium levels. Each of the above springs have a proportion of their catchments mapped as extremely vulnerable. Therefore landspreading of slurries, manures and inorganic fertilisers may be contributing to elevated potassium levels across the catchments, together with soiled water from farmyards.
- Five of the seven available Oldtown Clonown Group Water Scheme samples have a ratio above, or close to, the guide level of 0.4. These are mainly due to excessively high potassium levels (four exceed the EU MAC of 12 ml/l and one exceeds the GSI guide of 4 mg/l). This source is located is an extremely vulnerable setting over a locally important aquifer (Ll). Given the frequency of elevated potassium:sodium levels and the other elevated parameters at this source (nitrate, chloride, phosphate, faecal coliforms), it is likely that the contamination source is very local, possibly from nearly farmyards.

5.7 Iron and Manganese

Background: Although iron and manganese are present under natural conditions (groundwater in muddy limestones, shales and boggy areas), these parameters can also be good indicators of contamination by organic wastes. High manganese concentrations can indicate pollution by silage effluent and other high BOD wastes such as milk, landfill leachate and perhaps soiled water and septic tank effluent. More information is provided in Appendix I. The Rural Water Quality Monitoring Report (Roscommon County Council, 2000) highlights that nearly 50% of the sources exceed the EU MAC for iron (0.2 mg/l). It did not identify how many of these sources were groundwater abstractions. The report also states that 166 of 1098 *samples* exceeded the EU MAC for manganese (0.05 mg/l), from both surface water and groundwater abstractions.

Occurrence: Summary water quality information for each supply source is presented in Table 2 and in graphical form in Appendix III. Analytical results are presented in Appendix IV. Key points to note are as follows:

- Twelve of the 51 sources (13%) had samples in excess of the EU MAC for iron and/or manganese.
- Four of the sources exceeding the EU MAC for iron or manganese are Public Water Supply Schemes.

Variations with time: No long term trends are apparent in the available data sets.

Distribution: Key points to note are as follows:

• Of the Public Water Supplies, Ballinlough has elevated iron and/or manganese in two of seven samples, Mount Talbot, Rockingham and Silver Island Springs (Castlerea Urban Water Supply Scheme) have one of seven samples which is elevated in *either* iron or manganese. These incidences of elevated iron and/or manganese do not appear to be characteristic of the sources however, all of these spring supplies also have elevated faecal coliforms hence these problems are less likely to be associated with natural conditions.

- Similarly the Cloonmore Termonbarry Group Water Scheme (borehole supply) also has high faecal coliforms, which would suggest contamination.
- Six of the seven remaining Group Schemes (Ballinameen, Caran/Castleplunket, Cloonmore Whitehall, Compton/Quinn, Oldtown Ballinameen and Tartan/Scurmore) also have elevated ammonia. Ammonia, iron and manganese can be associated with reducing conditions in groundwater that are contaminated by organic effluent. However, given the absence of nitrate, chloride or faecal coliform problems in corresponding data sets, it is likely that these levels are associated with more natural causes, for example runoff from peat areas close to these sources. The remaining source (Spollen/Rogers) is located in Argillaceous Limestone (impure limestone). This source also has an absence of nitrate, chloride or faecal coliform problems hence the elevated iron and manganese may be associated with the nature of the bedrock.

5.8 Phosphate

Background: The EU MAC for phosphates in drinking water is 2.2 mg/l, which is rarely exceeded in Ireland. However the <u>principal</u> significance of phosphate is as a cause of eutrophication in surface water, thus the guide level is set as 0.03 mg/l P for ortho-phosphates as this may trigger eutrophication in some rivers. In most instances the groundwater contribution to surface water will be significantly diluted, but if eutrophication of nearby surface water were identified, this assessment would indicate whether contributing groundwater might be providing a *pathway* for phosphates.

Sources of phosphate include slurries, soiled water from farmyards, inorganic fertilisers, septic tank effluent and detergents. Phosphate is strongly adsorbed onto soil but can show enhanced leaching to groundwater in coarse subsoils, thin subsoils, and areas with a shallow watertable, amongst others (Kilroy et al 1999). Consequently, elevated levels in groundwater are generally associated with extreme vulnerability.

Occurrence: Summary water quality information for each supply source is presented in Table 2, and in graphical form in Appendix III. Analytical results are presented in Appendix IV. Key points to note are as follows:

- Forty-one of the 51 sources chosen for assessment have phosphate analyses. None of the samples exceeded 2.2 mg/l thus the phosphate levels do not represent a concern to human health.
- Of the 41 sources, 17 (41%) exceed the guide level of 0.03 mg/l P for ortho-phosphate on several occasions. A number of other sources just exceeded this value on one or two occasions; however given the infrequency of these very low levels, they are not considered to be an on-going problem. An explanation of the GSI guide level and the EU MAC is provided in Section 5.1.
- The 17 supplies include nine of the ten currently used Public Water Supply Schemes.

Variations with time: No long term of seasonal trends were evident.

Distribution: Results are presented in Figure 4 and the methodology is explained in Section 3.4.



Figure 4. Phosphate in Relation to Well Type.

Key points to note are as follows:

- The karstic spring supplies have the highest phosphate levels. This is not unexpected as karst springs are frequently associated with point recharge, extensive areas of extreme vulnerability and negligible attenuation once water (and contaminants) enters the conduit groundwater system feeding these springs.
- The highest value in the last few years was recorded in the Ballinlough Water Supply Scheme (Ballybane Springs); 0.11 mg/l P in September 1999. This was one of a number of elevated samples and indicators (potassium, potassuim:sodium ratio, faecal coliforms, iron and manganese) which suggests that slurries, manures and/or soiled water from farmyards may be contributing to phosphate levels across the catchment of the spring. This is also exemplified to a lesser degree in several of the other Public Water Supplies (Ballinagard, Castlerea, Keadew, Knockcroghery, Lecarrow and Rockingham). By inference, this may also be the situation in other similar limestone areas in Roscommon where part of the catchment is extremely vulnerability.
- Groundwater is likely to be making significant contributions to surface waters in some parts of Roscommon, for example the Ballinagard Spring contribution to the River Hind. Although the phosphates levels detected in the samples are relatively low and there will be a dilution factor, groundwater with elevated phosphates may be contributing to surface water quality problems e.g. eutrophication. Any investigation of such water quality problems should include assessments of possible groundwater pathways.

6 General Groundwater Quality Assessment of Supply Sources

6.1 Introduction

The previous section discussed the distribution of contaminant indicators in Roscommon. Section 6 aims to group supplies with a view to providing a prioritisation which could be used to plan additional action measures. The grouping methodology is described in Section 3.4. In essence, there are four groups, with supplies in Groups 1 and 2 having the highest levels of contamination.

6.2 Discussion

Figure 5 depicts the relationships between the numbers of supplies in the contamination groups with well type.



Figure 5. Contamination Groups in Relation to Well Type.

Points to note are as follows:

- Three of the supply sources (Carniska, Castlestrange and Mullymucks) have limited available data and thus a representative contamination category could not be determined. Of the 48 remaining supplies, 60% fall into Group 1, 23% in Group 2 and 17% within Group 3. No supplies have been categorised within Group 4.
- Well type appears to have some influence on the overall water quality as only boreholes occur in Group 3 (less contaminated supplies) and 82% of 28 springs are in Group 1 (most contaminated).
- The elevated contamination indicators identified in the boreholes in Group 3 comprise a combination of only ammonia, iron and/or manganese. In most cases, these supplies are located in close proximity to areas of peat or within impure limestones. Thus, even though the EU MAC has been exceeded in some cases, is it possibly that the elevated levels are a consequence of their natural surroundings.
- Despite the relationship between boreholes and better overall water quality, this relationship cannot be guaranteed; 30% still fall into Group 1.

7 Appraisal of Water Quality Issues at Specific Supply Sources

As discussed in Section 2.2, field hazard surveys have not been undertaken as part of this report. Assessments have been made on the basis of water quality data and cannot be used to link quality problems with specific enterprises unless they are accompanied by field hazard surveys. Nevertheless, in order to provide some initial guidance, the combination of contaminant indicators at each supply has been assessed in the context of generic hazard types. At the majority of supplies there is no clear evidence of the type of generic hazard. However, at a small number of sources the contamination indicators do suggest point source releases of domestic or agricultural organic wastes:

Elevated potassium:sodium ratio	→	indicative of a possible farmyard hazard nearby:				
Corraun Whitehall		Oldtown Clonown				
• - •	Ro	ckingham				
Combination of indicators such as faecal coliforms and ammonia	→	Possible septic systems and/or sewerage pipes and/or farmyard hazards nearby:				
Cloonmore Termonbarry	Peal	ke Mantuar • Oldtown Ballinameen				
• Ogulla •	Ratl	hmore				

8 Conclusions

- Elevated faecal coliforms are the main water quality issue faced in Roscommon groundwater supplies. Faecal coliforms are in excess of 0 counts/100 ml in at least one raw water sample from 78% of the supply sources examined. Further, at least one raw water sample from 57% of all supplies has greater than 10 counts/100 ml. The lowest levels of faecal coliforms are found in borehole supplies and the levels in spring were significantly higher. This infers that deeper abstractions and well-head protection, which help to prevent the ingress of surface water and shallow groundwater, are a positive step in improving water quality.
- Groundwater in the selected supply sources is generally of a good *chemical* quality. Within the selected sources, the groundwater from the deeper borehole supplies generally has a better quality than the water from spring supplies. This supports the idea that direct ingress from surface water or very shallow groundwater is a cause of contamination. Furthermore, springs in karstified areas are often directly linked to point recharge features (e.g. swallow holes, dolines), thus by-passing any attenuating capacity of the soil and subsoil.
- Nitrate levels in the samples were generally low. Only one source has a nitrate level in excess of 50 mg/l NO₃ which is likely to be related to a nearby farmyard source of organic waste. As with faecal coliforms, the lowest nitrate levels appear to be restricted to borehole supplies (65% have 5 ml/l or less).
- The contaminant indicators suggest that domestic or agricultural organic wastes, such as poorlymanaged farmyard 'dirty water' and poorly-located or poorly-constructed on-site wastewater treatment systems (septic tanks), influence groundwater quality across the county.
- Iron and/or manganese are in excess of the EU MAC probably as a result of the natural conditions (geological, peat subsoils and soil) in seven supplies and in excess of the EU MAC as a result of contamination in a further five supplies. Naturally high iron and manganese are expected in several aquifers in Roscommon.
- Phosphate levels do not cause a concern for human health. However, 41% of the supplies assessed have phosphate in excess of the 0.03 mg/l P guide level. These supplies included nine of the ten Public Water Supply Schemes, which are located in karstified limestone aquifers. This is a potential concern for eutrophication in surface waters, especially where the groundwater contribution to surface water is high. Thus where causes of surface water eutrophication are being investigated, groundwater pathways for phosphate should be included in the assessments.
- Natural water quality problems may also occur in Roscommon. Sandstones, shaly limestones, and the deeper, confined aquifers can be associated with iron and manganese problems. Hardness and limescale problems can be associated with the limestone aquifers, while low pH and corrosion problems can occur where the older aquifers coincide with thin or peaty subsoil cover.
- Forty-five of the 51 supply sources are located in karstified limestone aquifers which are dominated by conduit flow. Given the relatively high groundwater velocities in these rocks, contamination occurring in any extremely vulnerable part of the sources' catchments is likely to reach the abstraction point relatively unchanged.

9 **Recommendations**

- In order to try to minimise the potential for contamination, new supplies would ideally comprise boreholes drawing water from confined aquifers or from moderate to low vulnerability groundwater in areas away from point hazards such as poorly maintained farmyards. These boreholes would preferably be constructed so as to seal off shallow groundwater strikes and to eliminate the potential for surface water ingress to the well. The bottled water standards produced by the Irish Standards Authority give guidance as to the correct procedure for well production and maintenance (EOLAS, 1992).
- Hazard surveys are recommended for Group 1 and 2 sources to remove or improve contaminant hazards. For Public Supplies where source protection areas have been delineated, these surveys should be conducted within the source protection areas identified as part of the groundwater protection scheme. Priority surveys might first concentrate within the inner source protection areas (SI) of each supply. For supplies in karst areas, the SI will frequently include the entire Zone of

Contribution (ZOC). For Group Scheme and other supplies where no source protection areas have been delineated, surveys might best begin within an area between 200 m downslope and 500 m upslope for boreholes and between 50 m downslope and 1 km upslope for large springs. However, surveys for supplies in karst areas should also be undertaken in extremely vulnerable areas within the estimated ZOC.

• Sampling of raw water as well as treated water is recommended for all supplies on a regular basis. Full analyses (including major ions) are also recommended. The frequency of sampling is best determined by the degree of concern at each supply. The following is recommended:

Group	Number of Supply	Recommended Raw Water Sampling Frequency
	Sources in Each Group	
Group 1	29	At least <i>monthly</i> , until conclusions can be drawn on the origin of the contamination and appropriate alleviation measures are taken. Then down-grade to Group 3 sampling frequency.
Group 2	11	At least <i>quarterly</i> , until conclusions can be drawn on the origin of the contamination and appropriate alleviation measures are taken.
Group 3	8	At least quarterly.
Group 4	0	At least <i>twice yearly</i> .

In addition to the usual analytes, indicators of petroleum, sheep dip, pesticides and herbicides should also be examined, perhaps on a less frequent basis (e.g. twice yearly).

• Due to the presence of faecal coliforms in the majority of the Roscommon groundwater supplies, it is recommended that all private domestic supplies should have a disinfection system, such as an ultraviolet light system, installed.

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